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Quarterly Progress Report #4

For the period March 1, 1963 to May 31, 1963

On

THE USE OF STRAIN SOFTENING TO IMPROVE THE PROPERTIES OF REFRACTORY METALS

Contract No. NOw62-0725-C

To

BUREAU OF NAVAL WEAPONS

Washington 25, D. C.

By

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ABSTRACT

The molybdenum -0.5 titanium alloy was subjected to an increasingly large number of passes with a constant work roll size. The property improvement went through a maximum at a relatively low number of passes (ten).

Attempts to measure surface strains by use of a ruled grid yielded results that were too coarse to experimentally relate strain to work roll diameter. More refined techniques are to be used.

The unnotched tensile properties of the tungsten sheet were evaluated as a function of testing temperature.

RESULTS AND DISCUSSION

MOLYBDENUM

In the Previous Quarterly Report (1) the effect of roller-flexing with 3/8 inch diameter rolls (surface strain 14 to 15 percent) was studied. During the present report period, a systematic study of the effect of number of cycles was carried out using 1/2 inch diameter work rolls which developed a theoretical surface strain of 11 percent. Test results for 2, 10, 50 and 100 passes at room temperature are shown in Figs. 1 to 4 inclusive. The ductility minimum at -40°F. found after 100 cycles with the small rolls also occurred after two cycles with the larger rolls, but further cyclic straining eliminated it. The largest suppression of the transition temperature was obtained with an intermediate number of passes. This is most apparent in Fig. 5 in which the data curves of Figs. 1 to 4 have been superimposed. Ten passes with the intermediate size rolls resulted in the greatest property improvement so far obtained. Although sufficient data have still not been collected to detect significant trends, the NDT of the flexed plate appears to be relatively insensitive to number of passes. Two to one-hundred passes with a constant roll size suppressed the longitudinal NDT 40°F., while two to fifty passes caused the same lowering of transverse NDT. One-hundred passes appeared to suppress the transverse NDT still further, but this was accompanied by a ductility loss above NDT.

The use of 100 passes with the 1/2 inch diameter work rolls appears to be beyond the optimum flexing condition. This would imply that smaller rolls and the associated larger surface strains would produce even poorer properties with the same number of passes. In

Progress Report No. 3 however, 100 passes with 3/8 inch diameter rolls was found to be beneficial suggesting that the surface strains developed are not equal to the calculated values. An attempt was made to measure the strains by scratching reference lines on the plate prior to kinking, and then measuring the extension due to bending. The method proved to be too coarse to obtain reliable reading however, so that a photographic procedure for applying the grid will be tried.

Photomicrographs of flexed and tested samples were made. Typically the fracture does not follow the maximum normal stress direction, but forked so that the crack runs parallel with the grain direction. This, of course, is expected with poor short-transverse properties. A typical cross-section is shown in Fig. 6.

TUNGSTEN

In preparation for flexing the tungsten sheet, its tensile properties were obtained as a function of test temperature as shown in Fig. 7. Flexing of this material has not been attempted as yet however.

FUTURE WORK

The flexing of the molybdenum -0.5 titanium alloy will be continued, and the effect of transverse flexing will be studied. Attempts will be made to measure surface strains by photogridding.

REFERENCES

1. S. Mostovoy and E. J. Ripling, Quarterly Progress Report #3 on "The Use of Strain Softening to Improve the Properties of Refractory Metals", Materials Research Laboratory, Inc., Contract #NOw-62-0725-C, December-February, 1963.

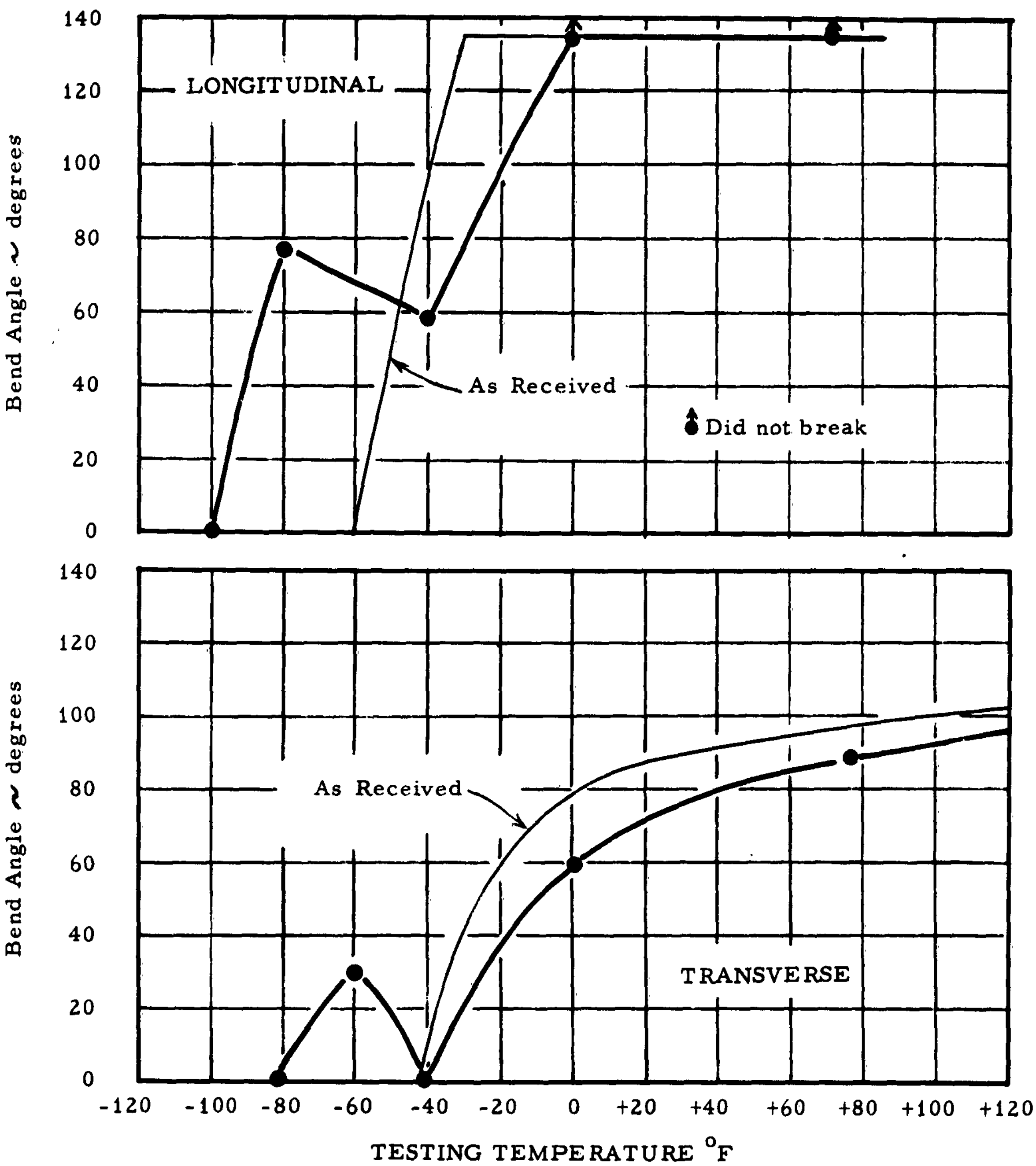

Fig. 1 BEND ANGLE vs. TESTING TEMPERATURE FOR MOLYBDENUM -0.5 TITANIUM ALLOY - FLEXED 2 PASSES AT ROOM TEMPERATURE - 1/2 INCH DIA. WORK ROLLS.

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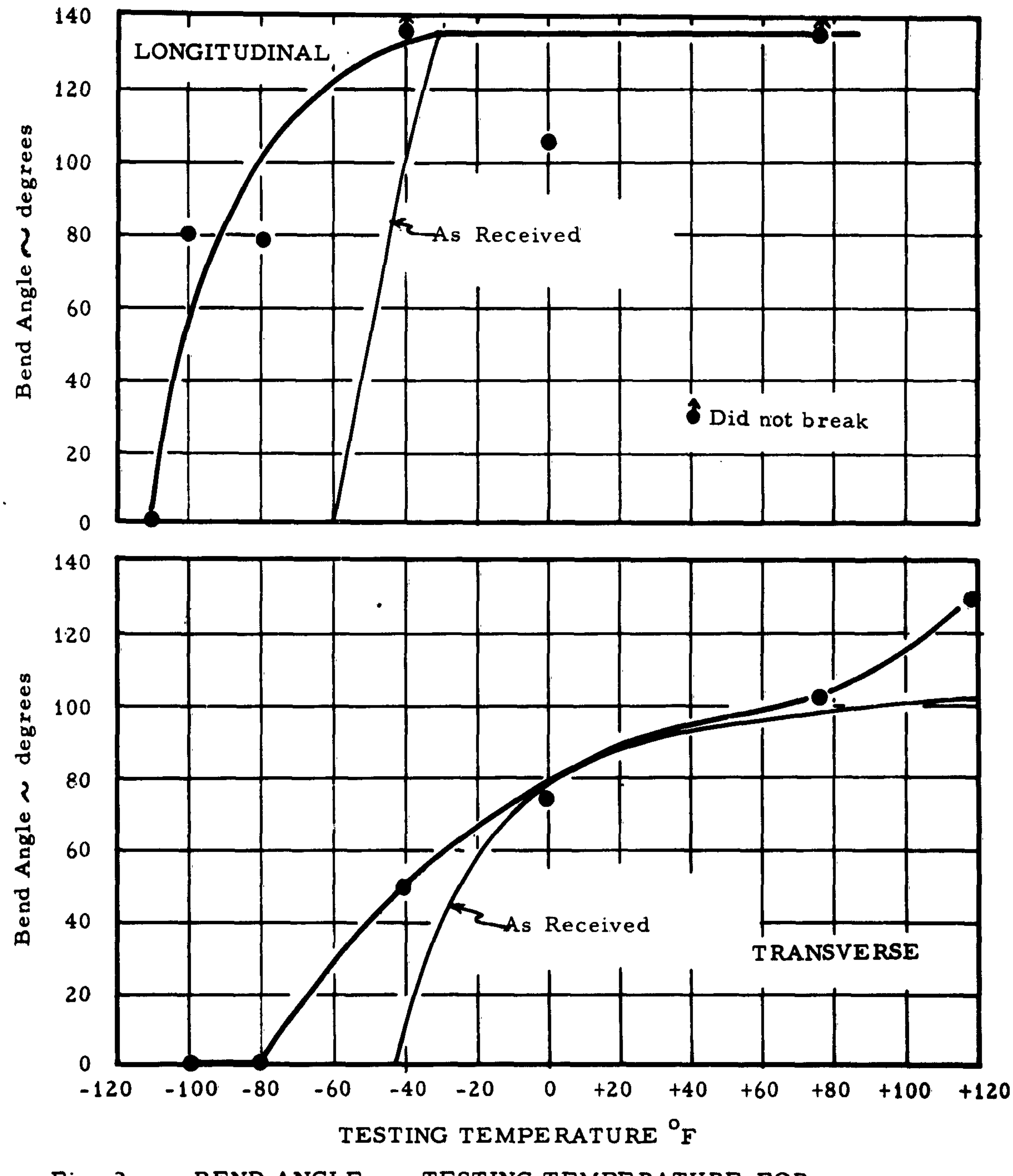

Fig. 2. BEND ANGLE vs. TESTING TEMPERATURE FOR MOLYBDENUM -0.5 TITANIUM ALLOY - FLEXED 10 PASSES AT ROOM TEMPERATURE - 1/2 INCH DIA. WORK ROLLS.

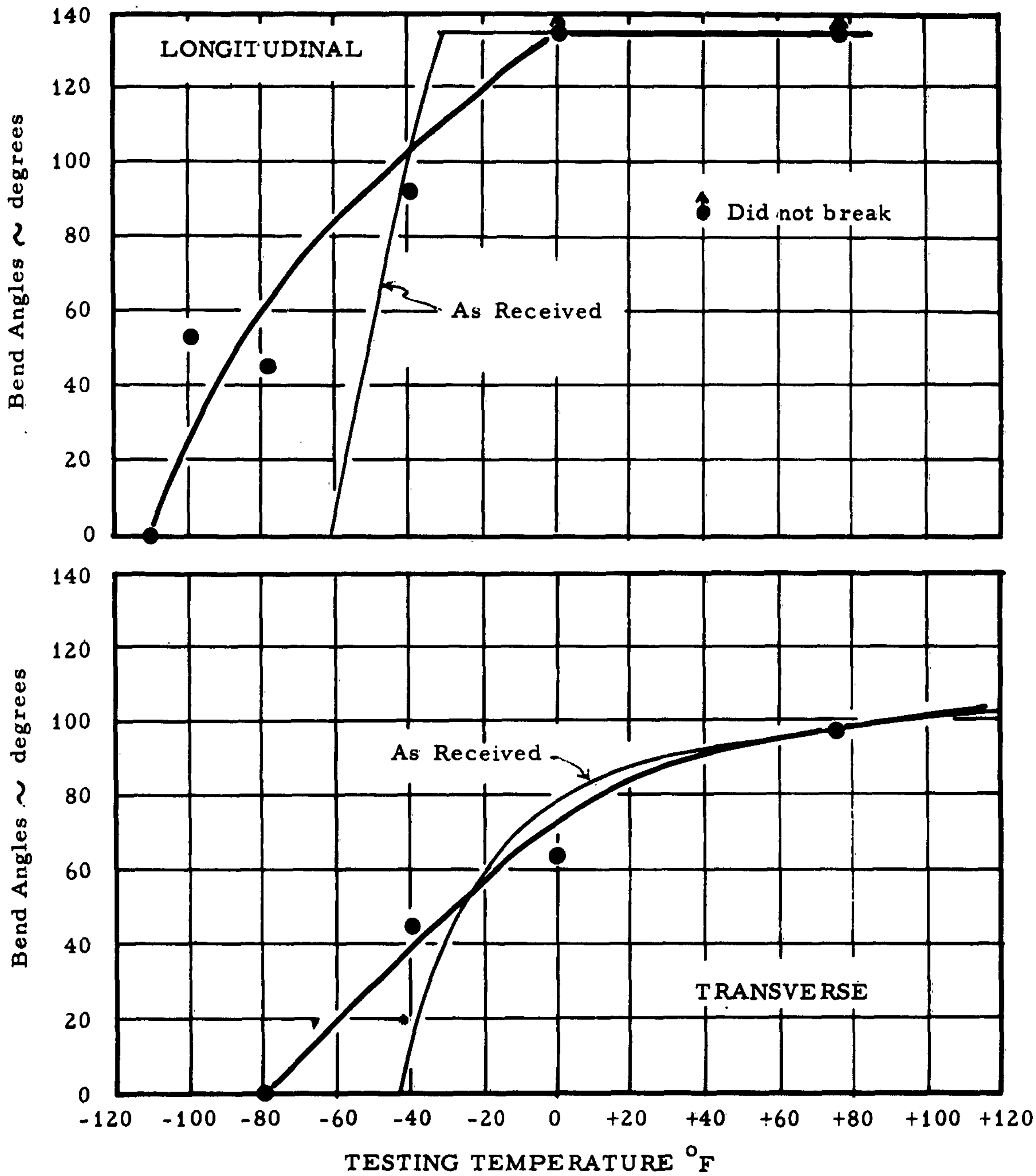

Fig. 3. BEND ANGLE vs. TESTING TEMPERATURE FOR MOLYBDENUM -0.5 TITANIUM ALLOY - FLEXED 50 PASSES AT ROOM TEMPERATURE - 1/2 INCH DIA. WORK ROLLS.

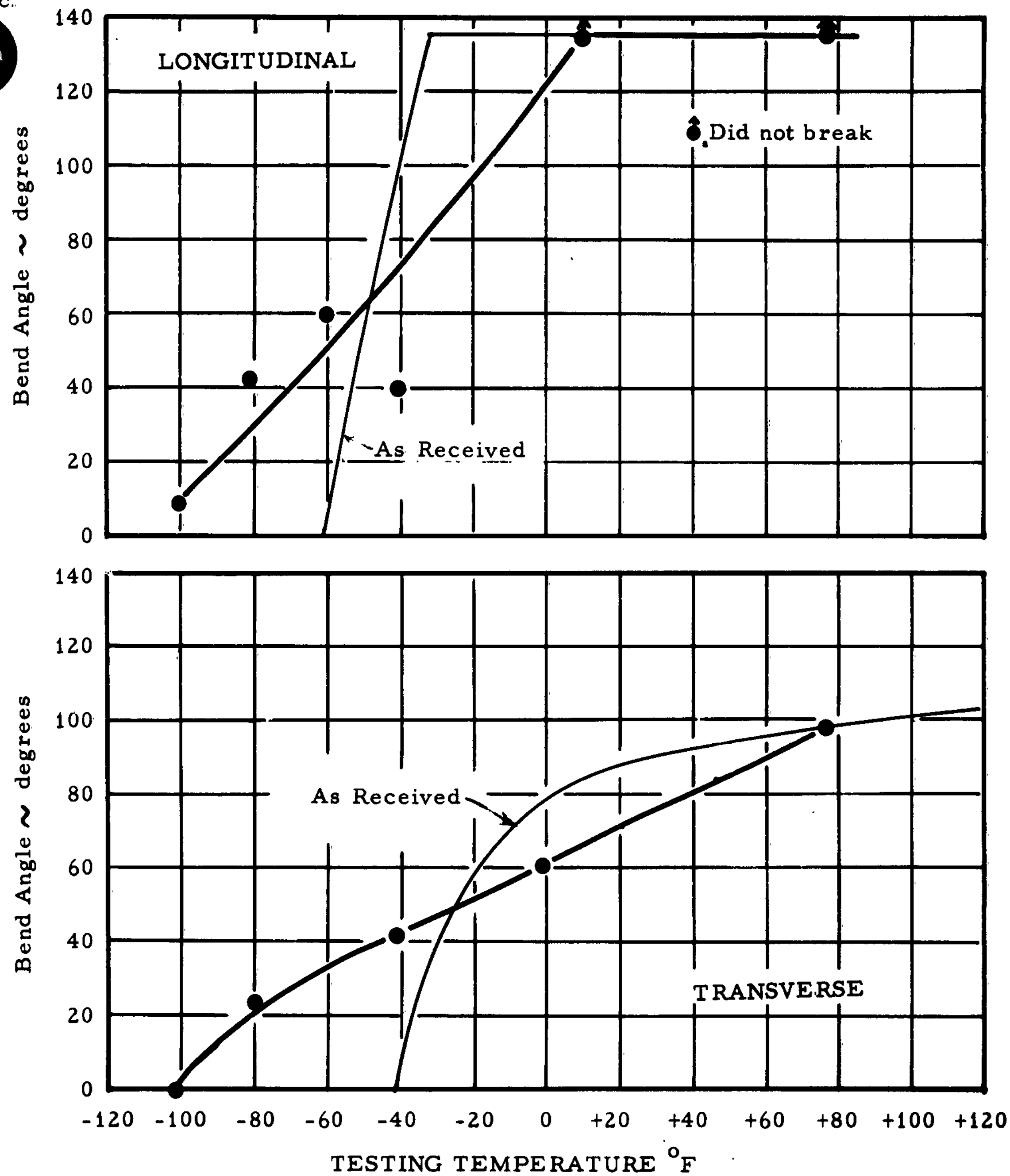

Fig. 4. BEND ANGLE vs. TESTING TEMPERATURE FOR MOLYBDENUM -0.5 TITANIUM ALLOY - FLEXED 100 PASSES AT ROOM TEMPERATURE - 1/2 INCH DIA. WORK ROLLS.

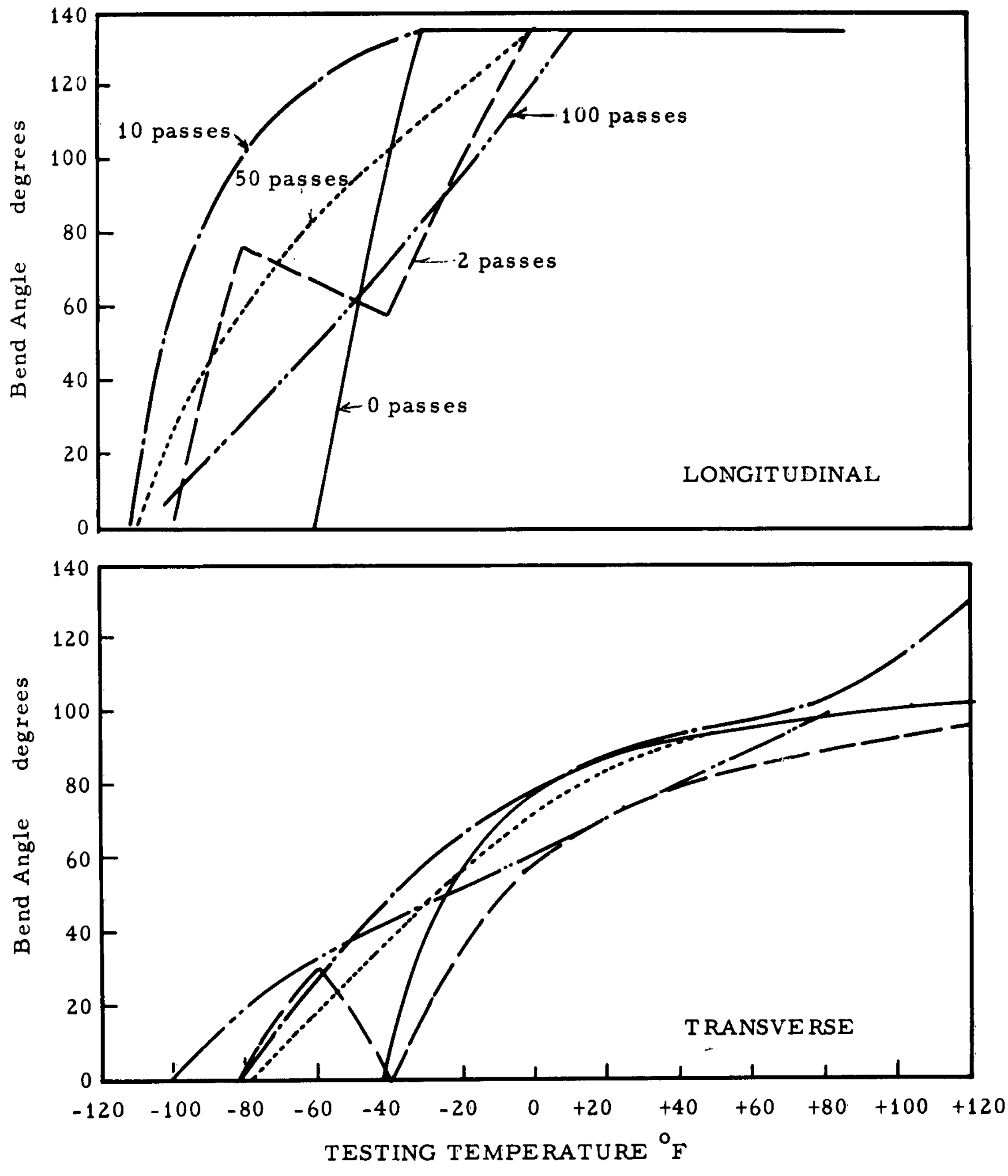

Fig. 5. EFFECT OF NUMBER OF PASSES ON LOWERING TRANSITION TEMPERATURE OF MOLYBDENUM -0.5 TITANIUM ALLOY.

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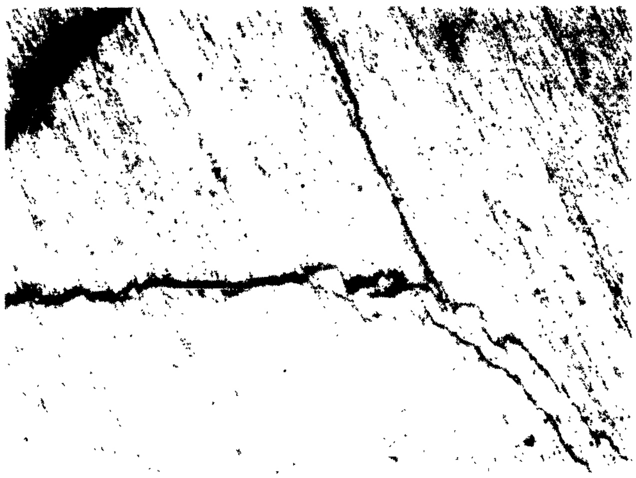

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Fig. 6 CRACK IN MOLYBDENUM SAMPLE TESTED AT $0^{\circ}F$. TEN PASSES AT ROOM TEMPERATURE.

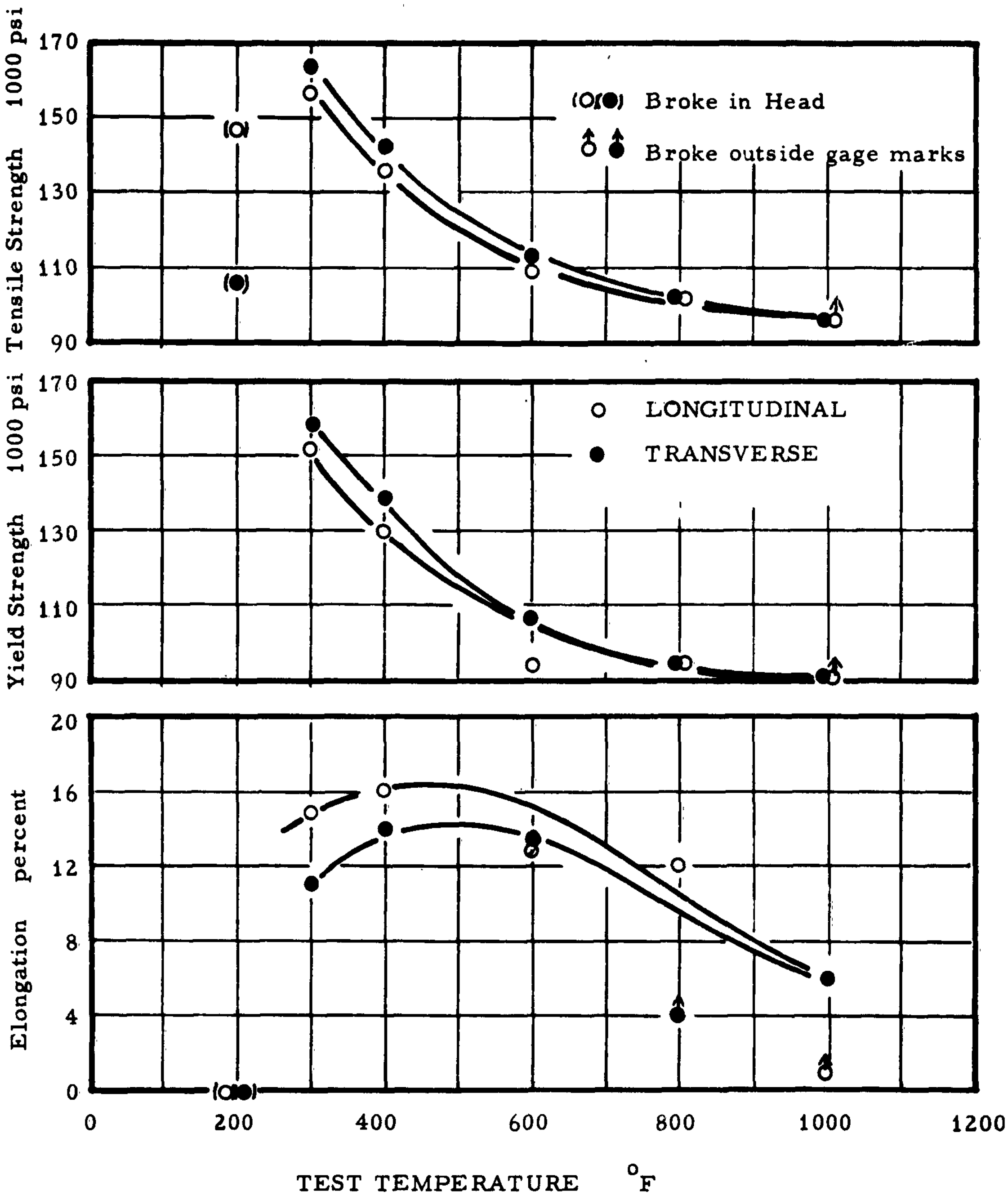

Fig. 7. TENSILE PROPERTIES OF "AS-RECEIVED" TUNGSTEN SHEET.